PAVEMENT DESIGN AND PROGRAMMING OPTIONS:

EUROPEAN DESIGN TO MAINTAIN ONLY

By

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Introduction

Traditionally, the Wisconsin Department of Transportation (WisDOT) periodically takes time to evaluate the effectiveness and wisdom of its pavement design philosophy as it relates to planning and programming issues. The range of options is quite large. On one end of the spectrum, there is a pavement management philosophy where a great deal of effort is placed in initial construction (very thick bases and pavement layers) and preventative maintenance (crack filling, minor patching, etc.). This has been euphemistically called a "Cadillac Pavement" or "European Pavement". On the other end of the spectrum, there is a philosophy of doing the absolute minimum effort (primarily routine maintenance and thin overlays) to keep the pavement useable. This is known as "Maintain Only".

Interest in this area most recently has expanded to include many people who have not typically participated in the debate in the past. This interest has extended into arenas such as the legislature and WisDOT policy makers. This paper is intended to provide background information related to the various options available to the planners, programmers, designers and maintainers of the State’s pavements.

The issues of investment strategy and design practices are typically discussed in terms of trade-off between cost (both up-front and life-cycle costs) and convenience to the public. One way convenience to the public can be evaluated is by examining the number of times that traffic is disrupted during the life of a roadway. The public has a sincere interest in minimizing the cost and inconvenience caused by construction and maintenance activities on their roads.

Historically, WisDOT has taken the stance that it will provide a "reasonable" level of service for a "moderate" cost. In recent years, there have been moves worldwide away from this philosophy in both directions. One direction, common for high-type facilities in Europe, is to put a great deal of effort up front to provide a massive pavement (in terms of both structure and costs). In the other direction, many agencies have begun to explore the concept of "maintain only" roadways where reconstruction efforts are minimized, and effort is concentrated only on maintaining a driving surface.

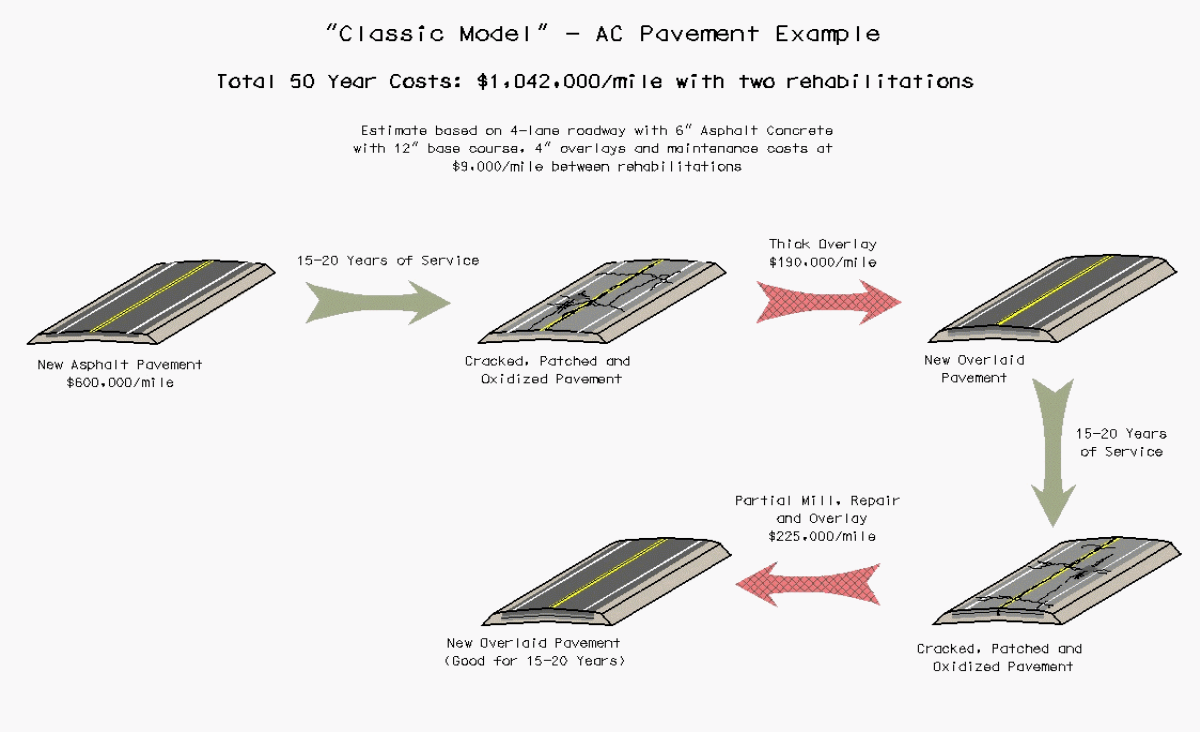
Rather than discuss the details of pavement design (materials, unit costs, life cycle costs and so on), this paper will examine the basic impacts of the three prevalent philosophies in broad terms of out-of-pocket cost and construction impact on the public. In each case, the evaluations are based on pavements that would be expected to have equivalent performance over time. The variables become the timing, frequency and type of activities that would take place during the 50-year analysis. Discounted life cycle costs were not included because of the variable nature of when a rehabilitation cycle occurs and the effect of the discount rate skewing results because of these specific timing issues.

The "Classic Model" will discuss current practice, the "European Model" will discuss the maximum effort scenario, and the "Maintain Only Model" will discuss the minimum effort alternative.

Classic Model

In the "Classic Model," pavements are designed such that they will convey expected traffic loads for 15-30 years (depending on design, life cycle costs, and construction materials used). This initial construction is then followed with combinations of overlays and rehabilitation (patching, repairing, milling, etc.) efforts. These efforts are expected to last 10-20 years each, depending on the type and design of the initial construction and the condition of the roadway when the rehabilitation is done. Normally a design is expected to accommodate two overlays before reconstruction is required again.

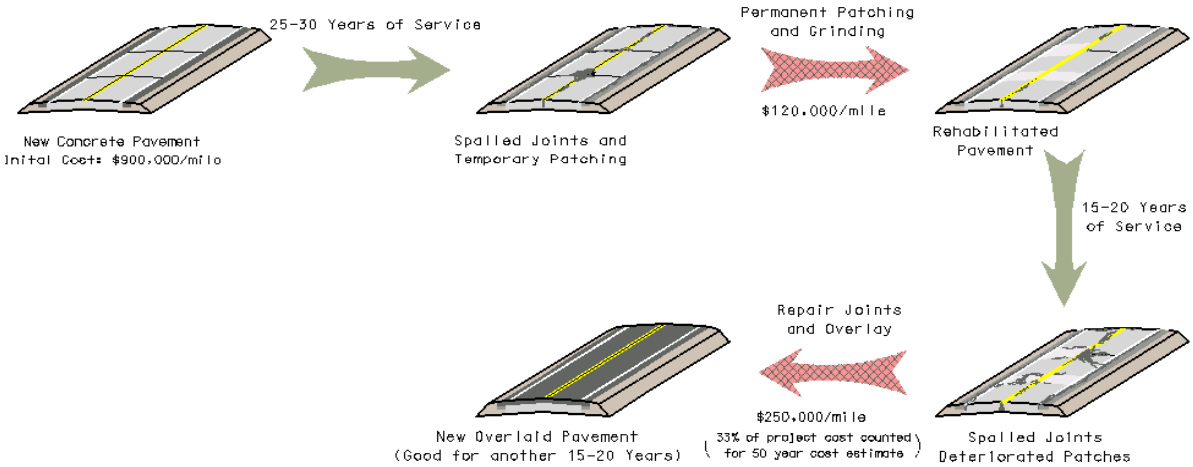
Total cost for the life of the pavement (typically 50 years) can vary a great deal and is dependent on the type and volume of heavy truck traffic carried on the facility, the environmental conditions and the measures/thresholds for determining when rehabilitation occurs. Lower standards for construction and performance thresholds are typical for less traveled routes. The total 50-year cost of a typical 4-lane pavement design for a major roadway will be $1,000,000-$1,250,000 per mile and for a two-lane roadway will be $500,000-$600,000. During the 50-year life, two or three rehabilitation projects would be expected. The figure below outlines a typical scenario for this model.



"Classic Model" - PCC Pavement Example

Total 50 Year Costs: $1,127,000/mile with 2 rehabilitations

Estimate based on 4-lane roadway, 10" Jointed Plain PCC with dowels on 10" of drained base course. Overlay is 4" AC pavement. Estimate includes $24,000/mile of routine maintenance.



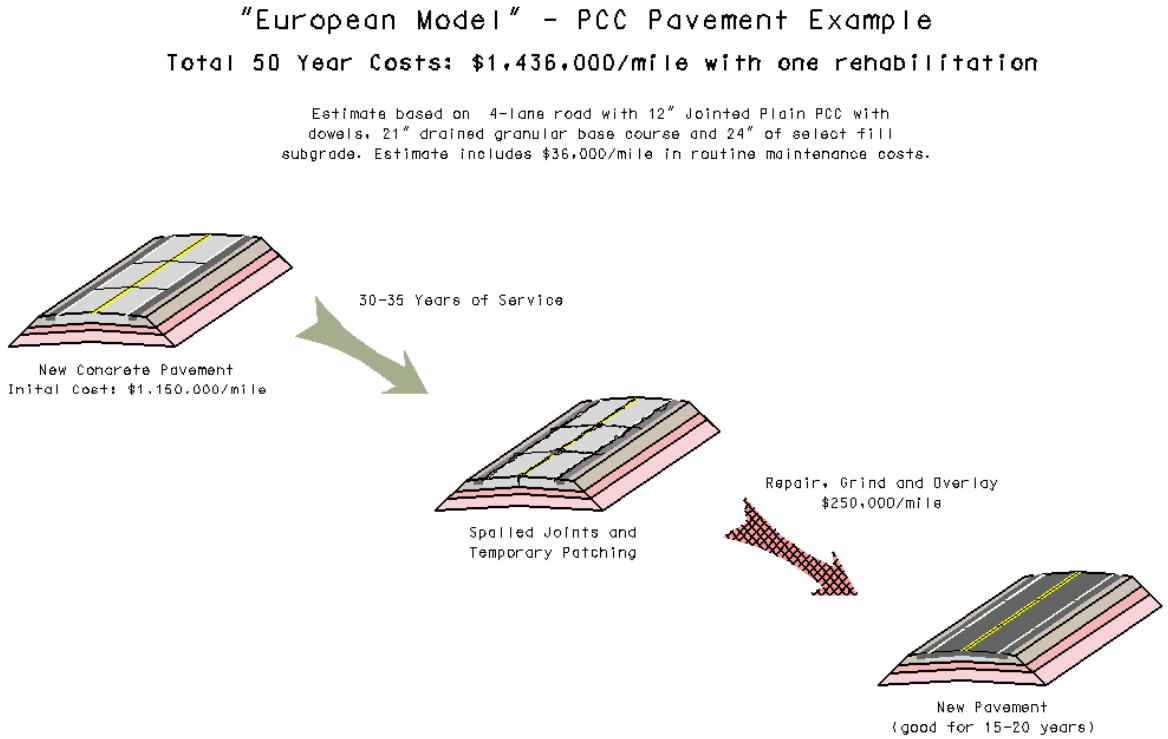
European Model

The "European Model" varies from current practice in that more effort is placed in the work done during initial construction. Typically, the pavement structure is improved by providing wider roadways (spreading out the stress more) and deeper pavement structure. The total pavement structure is generally twice as thick as those normally built (particularly in the base and subbase) in Wisconsin. The intent of this improved structure is to maximize the initial life of the structure, to minimize the need for maintenance and rehabilitation, and to improve the ease of future reconstruction.

Total costs for this option are larger than the "Classic model," most of which is born in up-front costs. However, the maintenance costs and rehabilitation costs may be substantially less. For a typical four-lane pavement design, the 50-year costs for a typical four-lane road would be $1,400,000-$1,500,000 per mile and for two-lane facility, $700,000-$800,000 per mile. Only one rehabilitation is typically required in this model.

It should be noted that the Europeans also do a lot of preventative maintenance work (including thin overlays) to maintain the roadway surface. The general practice is to repair any blemish on the surface when it occurs. This is done because of the risk of "loosing" the large investment that has been made. This practice is being repeated by those agencies in this country that are attempting this method of operation.

An example of the "European Model" is illustrated below.



Maintain Only Model

In this model, no effort is made to reconstruct pavement structures. The minimum treatment that is appropriate for a structure and its current condition are considered. It should be noted that the initial minimum rehabilitation should still have a life of 10-12 years. Subsequent rehabilitations will have reduced expected lives. Ultimately, the expected life of each rehabilitation should level off at 5-7 years. Pavement structures, the older underling structure in particular, simply wear out and provide less support over time.

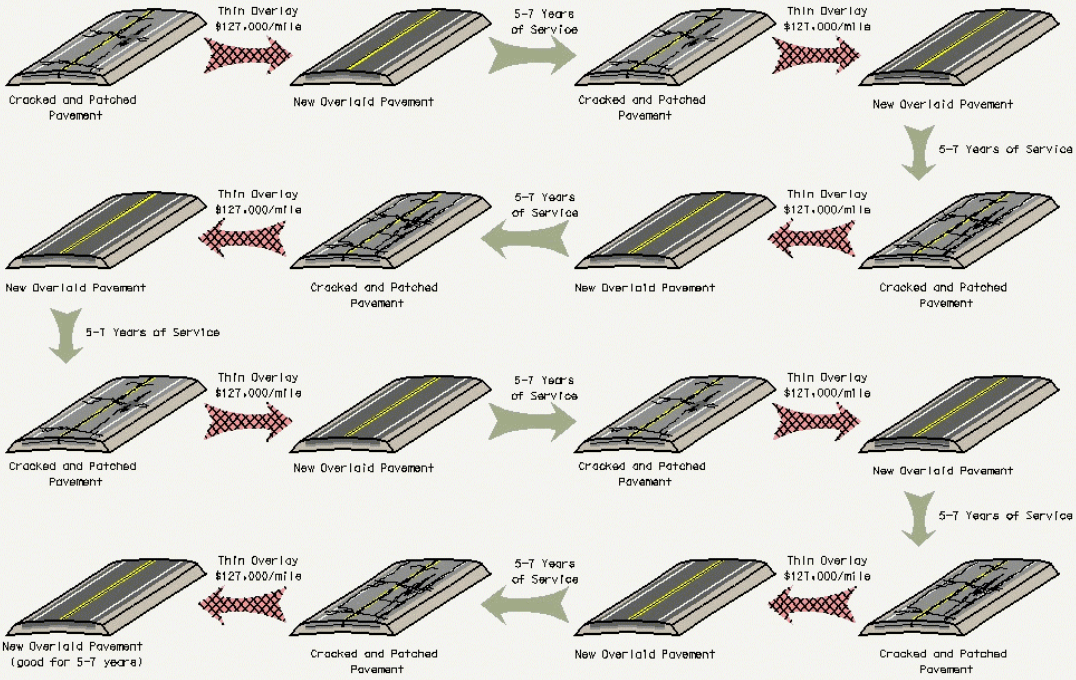
Initially, the costs for this strategy are substantially less than those of the other two models. However, the amount of traffic disruption resulting from frequent construction is much greater and the steady deterioration in expected pavement life will result in much higher costs. The most optimistic example of this strategy would begin with the first overlay. The expected number of overlays over 50 years would be 5-8. The costs for this alternative would be $650,000 to $1,100,000 for a four-lane facility and $325,000 to $550,000 per mile.

It should be noted that the majority of the system does not follow the optimistic scenario above as most roads have at least one overlay already. The overlay that can be expected to last 10-12 years has been and gone. The lag in expected life deterioration (from 10-12 to 5-7 years) has already been realized. The worst case scenario is one where the roadway has already been rehabilitated several times and the expected life of additional overlays has plateaued at 5-7 years. In these cases, the number of rehabilitation cycles climbs to 7-10 overlays over 50 years. This situation is illustrated below and the ultimate cost of this scenario would be $900,000-$1,300,000 for four-lane roads and $450,000-$650,000 per mile for two-lane roads.

"Maintain Only Model" - Previously Overlaid Pavement Example

Total 50 Year Costs: $1,080,000/mile with 8 rehabilitations

Estimate based on 4-lane road with repeated 2" mill and overlay projects. Etimate includes $9,000/mile between each overlay for routine maintenance costs.



Summary of Analysis

This table summarizes the commentary above.

	Cost ($x1000)		Number of
Model	4-lane highway	2-lane highway	Rehabilitaions
European	1400-1500	700-800	1-2
Classic	1000-1250	500-600	2-3
Maintain Only* 0 overlays 1 overlay 2+ overlays	 650-1100 775-1200 900-1300	 325-550 400-600 450-650	 5-8 6-9 7-10

* difference in cost is dependent on the number of overlays already in place before the "maintain only" strategy begins. This represents the effects of reduced expected life.

Comments

There are many factors that relate to pavement failure. A pavement is exposed to extremely harsh and destructive forces. Wisconsin's severe climate and drastic swings in temperature coupled with heavy truck loads conspire to create a particularly difficult environment for a pavement.

The three basic causes of pavement failure are an unstable base, failure of the paving material or design, and inadequate structure for the actual loadings. During winter, frost depths go well into and below the pavement structure, damaging the underlying base. During the spring, the pavement structure is saturated with water and salt and the destructive forces of freeze and thaw combine to wreck the structure. Finally the pavements are continuously pounded by heavy truck loadings. Pavements can fail due to poor base (frost susceptibility) , poor materials (freeze/thaw effects) or poor design (loading issues). Anyone of these failure modes can cause a pavement to fail.

Some anecdotal evidence exists for the performance of the "European Model" and "Maintain Only Model" in comparison to the "Classic Model." The following summarizes some of those observations.

European Design: Many of the European countries, particularly those the in the European Common Market have invested heavily in deep pavement structures and are generally satisfied with their performance. The European countries typically run heavy loads on their roads and have a mild climate. The combination is ideal for the successful implementation of this design. The pavement structure includes a deep base to get below European frost depths (note, in Wisconsin frost depth often exceeds six feet). The mild climate reduces the need for the use of road salts, thereby reducing durability problems. The deep base and thicker pavement layer allow the conveyance of heavy loads.

Several states have also experimented with this type of design, but meaningful results are not yet available. One state, New York, has expressed some concern because many of their pavement failures are due to non-structural problems (material durability, surface distress, thermal cracking, etc.) which the European design does not address because of the climactic differences.

It should also be noted that demographics in this country work against this method. Distances between population centers are much greater in this country. To put this problem into context, if we were to have used this method to build the interstate from Madison to LaCrosse, and were given no more money, the road would have only gotten to Tomah.

Maintain Only: A few state DOT's have adopted the "Maintain Only" method to some extent. In some states it is common practice to place overlays every 4-8 years. The typical failure mode is usually structural in nature, and it is accelerated in poor climates. Because the underlying pavement structure has deteriorated, cracks reflect up through the new surface. This usually occurs quickly and is exacerbated by poor climate. With the harsh

climate in Wisconsin, it is highly questionable whether the ultimate overlay cycle would be any better here. This in turn will likely lead to an increase in the backlog of roadways needing attention because of the short lives.

Research: It should be noted that most of the research done on pavement structures have centered on the "Classic Model" and enhancing that model. In may ways, the "Maintain Only" and "European Model" are simply extreme cases of that research. On one hand, research is looking into methods to produce inexpensive short term solution and on the other hand, effort is being put forward in increasing the strength and durability of long term pavement performance. All of these efforts are centered around enhancing the "Classic Model", making them less expensive, more durable and longer lasting.

Considerations

The following should be considered for future pavement design practices at WisDOT:

Use the Classic Model on the majority of highways in the system. This option is a good compromise between cost and number of major traffic interruptions for the driving public.

Evaluate the European Model for use on high volume highways. This option may offer significant benefits on those sections of highway where any interruption of traffic is a major problem that should be avoided at any cost.

Evaluate the Maintain Only Model for use on low volume highways. This becomes a viable option on those roadways where there is minimal impact from traffic. The cycle presented above (5-7 years between overlays) can be extended significantly if there is minimal heavy truck traffic. Also, options such as cold recycling are available and may be a viable option.

The "Classic Model" has provided worthy service to the public. Performance is neither exceptional nor unacceptable. Although there is always room for improvement, this methodology has provided good service to the driving public. There are no indicators that this will change in the near future.

The "European Model" offers excellent performance for a high price tag (15-20% higher costs than the classic model). There is a potential for the use of the "European model" in large urban areas and high volume routes where any disruption of traffic would be a major problem. There simply is not enough proof that these types of pavements will have the durability to be truly maintenance free for 30+ years, thereby making it difficult to strongly recommend this approach.

The "Maintain Only" model will initially save some money but will be more expensive in the long term because of the deterioration in rehabilitation life and disruption to the public. There is also potential for the "Maintain Only" on pavements where marginal performance will have minimal impact on traffic. This strategy should however be avoided on the majority of highways because of the shortened life cycle over time.

Finally, it should be noted that these strategies have impact on the system as a whole. The distribution of performance can be shifted by changing the balance between these options. When using the "Classic Model" the distribution tends toward a system where the bulk of the roads are adequate, some are very good and a few are very poor. In the "European Model" there will initially be a build up of pavements moving from adequate to poor and, unless substantial increases are made in investments, the distribution will likely stayed skewed to the poor end of the spectrum as need will exceed ability to deliver. With the maintain only strategy, there will be a shift from very good pavements to poor and adequate pavements because the overlaid pavement simply doesn’t perform well for very long.